Space Weather Technical Forecast

Issued on Tuesday, 30 January 2024 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of further R1/R2 Radio Blackouts. Possible glance from CME and Chance of G1 day 2 (31 Jan). Ongoing S1 conditions likely easing into the period.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as measured by GOES16, rose sharply to Moderate in the past 24 hours, with previously subdued occasional C-class activity showing an increased cadence and amplitude to culminate in an M6.8 from AR3559 at 29/0438UTC. This was a long-period flare and was accompanied by an energetic Coronal Mass Ejection (CME), an EUV wave and marked coronal dimming, as well as a Type II radio burst. Analyses of the ejecta imply that the 512km/s Type II may represent a harmonic, with speeds nearer 1000km/s preferred from analyses. This CME showed a partial halo shock, however the main thrust of the CME is expected to pass west of the Earth, crossing 1AU early in the UTC day of Wednesday 31 January. No other Earth directed CMEs observed in available imagery.

There are currently six sunspot regions on the disc, including three as yet unnumbered regions - one in the southwest, one in the southeast and one rounding the northeastern limb. Limb foreshortening is now preventing further analysis of AR3559 on the northwestern horizon, this also true for AR3560 in the southwest. AR3565 in the east has shown some slight development, still comprising one main north-south aligned delta spot but with some trailing activity developing. Limited flare activity from this region so far but it will continue to be monitored. The as yet unnumbered region rounding the northeast limb appears moderately active though the current foreshortened view makes accurate analysis difficult and liable to change in the coming hours and days.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR and ACE at L1 showed an intermittent weak fast wind regime likely associated with the increasing influence of CH94 and CH95, both negative. The solar wind varied from background to slightly elevated levels, between around 380-480km/s. The solar wind density trace was less clear - with ACE showing generally below average around 2-5ppcc, whereas DSCOVR showed more variable output and is not preferred. The IMF was weak throughout , around 3-7nT, with the north-south component varying between +6 and -6nT, with an erratic character. The Phi angle was predominantly negative (towards the Sun).

The net result of the above solar wind measures was for provisionally Quiet to Unsettled geomagnetic activity.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux showed a sharp and almost immediate rise across all measured energies in the wake of the M6.8 flare, with 10MeV peaking and subsequently plateauing at around 33pfu, while 100MeV peaked around 0.6pfu. This implies a relatively direct connection to Earth at present, as also hinted at by the 'snow' observed on imagery following the event. 10MeV values saw a second

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rise from around 29/1300UTC, first to around 70pfu and then again from around 29/1615UTC to a peak of 140pfu around 29/1805UTC below slowly declining.

GOES16 high energy (greater than 2MeV) electron flux was at Normal Background. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a generally steady trend. At 30/0001UTC the 24-hour integrated fluence observation was 1.22e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Chance of further M-class flares and a Slight Chance of isolated X-class flares in the near term. This risk reducing somewhat into the period as AR3559 fully departs the visible disk around midweek UTC.

Solar Wind / Geomagnetic Activity: Generally Quiet to Unsettled condition expected in association with coronal hole influence initially, with a chance of Active intervals. The peak risk of geomagnetic activity into day 2 (31 Jan) associated with the expected shock arrival from the 29/0438UTC CME, with Active intervals likely and a chance of G1 Minor Geomagnetic Storms.

Energetic Particles / Solar Radiation: High energy proton flux is Expected to remain above S1 in the immediate term, with a decreasing Chance through the first half of the UTC working week as flux levels are expected to wane in the absence of any further flare enhancement.
The high energy electron flux (greater than 2MeV) is relatively low confidence due to near-term coronal hole influence, however exceedance of Active is deemed unlikely throughout.

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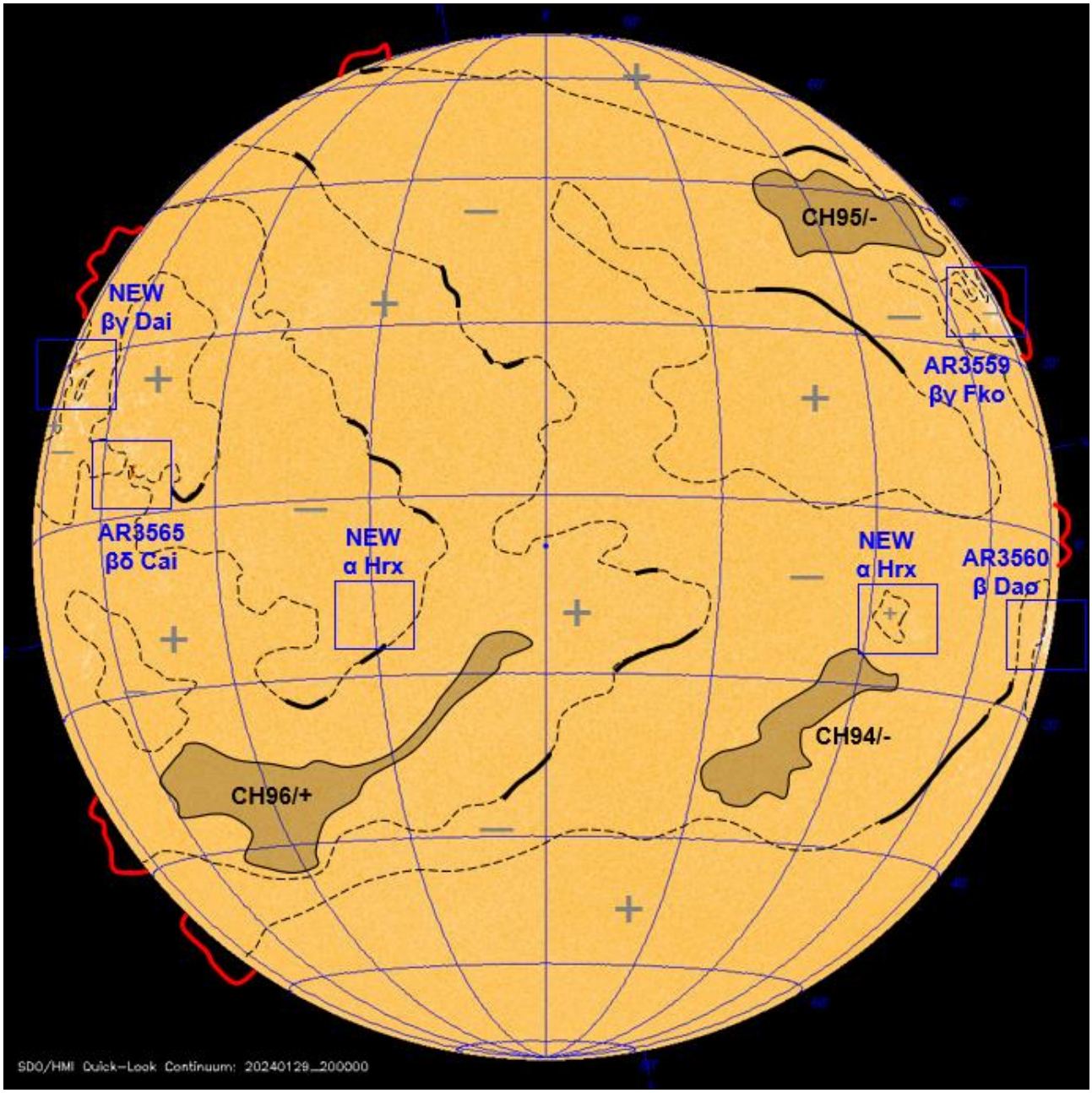
Figure 1. Solar Analysis Valid 29/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one CME that currently features in the forecast - that from the M6.8 from AR3559 at 29/0438UTC. MOSWOC Enlil modelling of this feature suggests the main bulk of the ejecta will pass well west of the Sun-Earth line early in the UTC day of Wednesday 31 January. Having said this, the shock clearly shows a partial halo component. As things stand, the CME crosses 1AU ahead of Earth early on day 2 (31 Jan), with some ensemble members seeing a faint Earth glance from the flank later in the day. There is a Chance of G1 Minor Storm periods, probably contained within the UTC day of 31 January. MOSWOC Enlil's initialised solar wind speed is currently slightly in error - nearer 550 rather than the observed 475km/s, which should serve to move any CME arrival later and therefore more wholly contained within that UTC day (31 January).

Current solar wind conditions are indicative of a minor coronal hole fast wind enhancement, with the source likely some combination of the recurrent CH94 and CH95, both negative. Their influence expected to persist through day 1 (30 Jan) perhaps seeing speeds increase towards Elevated levels around 500km/s, before declining into day 2 (31 Jan) with persistence suggesting only a small chance of significant geomagnetic activity in association.
All considered, generally Quiet to Unsettled condition expected with a chance of Active intervals initially and the peak risk of geomagnetic activity into day 2 (31 Jan) associated with the expected shock arrival from the 29/0438UTC CME.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	40	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/0753	Partial	AR3559	NW Limb	1150 km/s	31/0600-1800	Shock expected with bulk of ejecta expected to miss.

Figure 2: Latest MOSWOC Enlil ensemble (badge time 29/2000UTC). Note that although the deterministic run remains unperturbed, a minority of ensemble members do show degrees of glancing incidence, and this is without explicitly modelling the enveloping shock. Also of note is Enlil's somewhat overly-fast modelled background wind, which implies the CME may arrive very slightly later than shown, although this is not the dominant source of uncertainty and the effect likely small given the fast emission speed.

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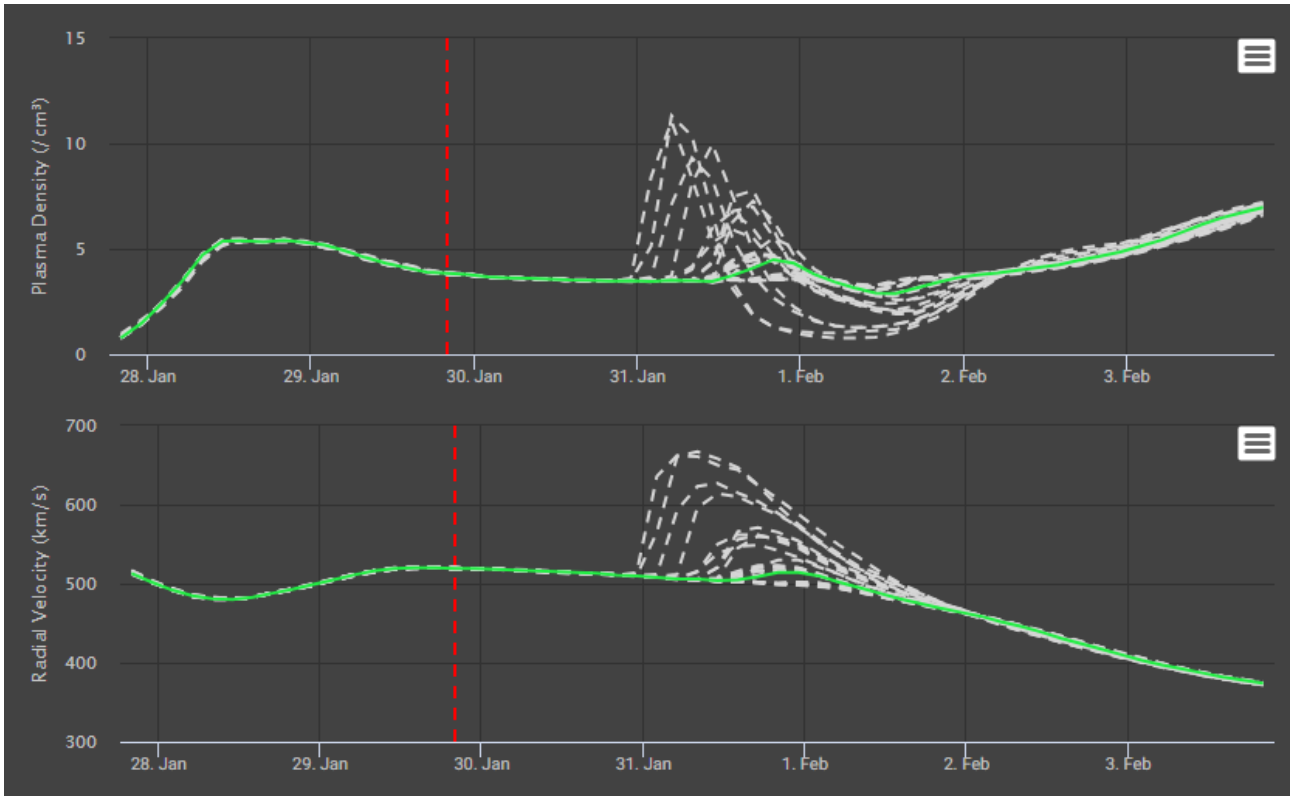

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Radio Blackouts - X-Ray Flares:
While the current disc is currently presenting a relatively sparse face, there are a number of complex regions that occupying both limbs. Foreshortening effects continue to hamper analyses, especially of AR3559, which also suffers for being north on the disc at a time when Earth is well south of the solar equatorial plane. These effects also applying to the as yet unnumbered region rounding the northeast limb which appears moderately active, its classification liable to change in the coming hours and days.

The chances of further M-class activity have been revised upwards from the raw disc values in the near term given the recent activity associated with AR3559. This region in the process of approaching the limb through the next 24hrs but the risk of flare activity maintained into the start of the forecast, reducing gradually as this group continues to rotate away into midweek UTC. The balance of active regions on the facing side is expected to be fairly constant in number but probably not potency, with the departure of AR3559 and AR3560 expected fully into day 2 (31 Jan), and with AR3559's flare looking currently unlikely to be matched by any east limb arrivals, a general decrease in flare risk is likely.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	40	30	30
Very Active	R3 to R5 X Class	No	5	5	1	1

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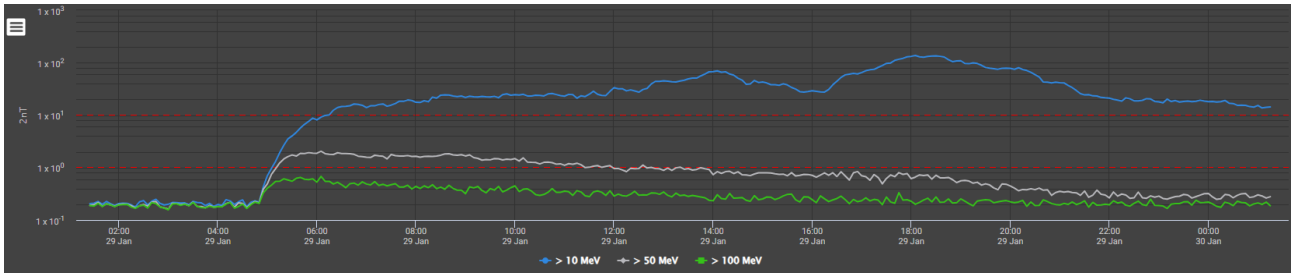
Solar Radiation Storms - (High Energy Protons):
GOES18 high energy (greater than 10MeV) proton flux showed a hard spectral response to the 29/0438UTC M6.8 flare from AR3559, with very little transit delay to L1 and Earth. All measured energies showed an uptick and initial plateau, followed by a further increase in flux now looking to slowly be easing.

The evolution from here depends on how many further suitable flares might be produced, with it unclear as to whether AR3559 remains significantly unstable presenting a risk of further proton-producing flares given the highly foreshortened viewing angle. The risks of breaching the S1 threshold is maintained into day 1 (30 Jan), with flux expected to slowly ease later day 1 or perhaps into day 2 (30-31 Jan) in the absence of further flare enhancement.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	90	30	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Latest 24hr GOES18 Proton Flux trace.



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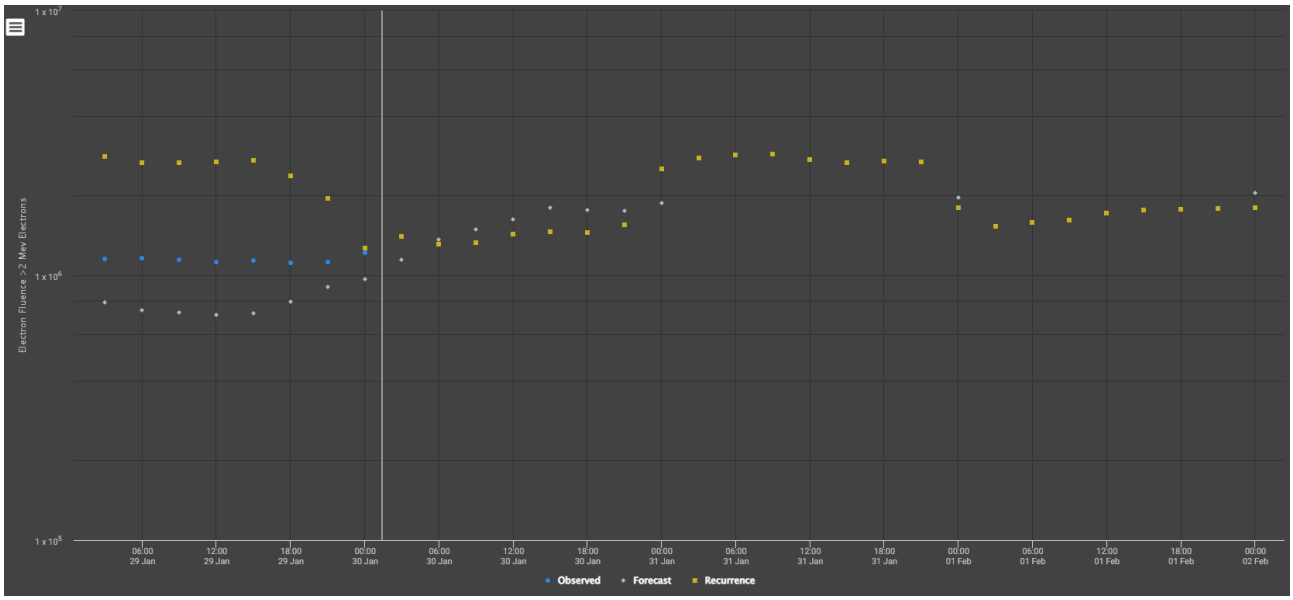
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) has spent the whole of the past 27-day rotation below High levels, with an absence of significant drivers to alter this state given the expected lack of potent coronal hole fast winds. Persistence suggesting significant electron flux is unlikely following the current ongoing solar wind enhancement associated with CH94 and CH95, although the latter is at a high solar latitude for any Earth effects.

MOSWOC REFM's projections and persistence values both imply a continuation of the current quiet state, and this is the preferred forecast even with the likely further influence of CH94 and CH95, although this risk increasingly slightly into the period.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	5	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: Latest MOSWOC REFM model output.



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